The Role of Cetaceans in the Shelf-Edge Region of the Northeastern United States

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Introduction

Man has been, and continues to be, a part of the ecosystem along the outer margin of the outer continental shelf (OCS). With oil and gas exploration and development added to the present fishing and shipping activities, this role may be on the increase. After 3 years of field studies, the role of another group of apex predators, marine mammals, can be characterized. These findings have application to decisions about resource utilization, habitat use, and the impacts of offshore activities.

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In this study, the shelf-edge region was defined as bounded by the 91 and 2,000 m depth contours, and by lines extending southeast from Cape Hatteras, N.C., and from the center of the Northeast Channel at the eastern tip of Georges Bank (Fig. 1). This region straddles the shelf break (200 m depth contour), is about 40 km (21.6 n.mi.) wide, and includes about 62,100 km^2 (18,100 n.mi.^{2}).

This paper summarizes aspects of the findings from a large and multifaceted study. Details on sampling and data collection not included here are given in the final report of the Cetacean and Turtle Assessment Program (CETAP),

Three sperm whales (two adults and a calf) sighted by survey aircraft in deep water south of Georges Bank.

University of Rhode Island[1]. Additional findings on cetacean biomass and energetics in waters of the northeastern U.S. are reported in Scott et al. (1983). A review of morphology and energetics in relation to the food requirements of marine mammals is provided by Brodie (1984).

The principal findings reported here are:

1) Twenty species or species groups were reported in the region. Of these, 12 are common and 8 are uncommon or rare. Three species, the sperm whale, *Physeter catodon;* fin whale, *Balaenoptera physalus*; and pilot whales, *Globicephala* spp., together constitute >75 percent of the cetacean biomass.

2) During the season of peak abundance, spring, a minimum of 47,565 cetaceans may inhabit or transit the region. This represents a cumulative biomass of 26,506 metric tons (t).

3) The food requirement of the shelf-edge cetacean component is estimated to be between 64,000 and 960,000 t/year. The current best estimate within this range is 480,000 t/year. This value converts to a cetacean consumption of 9.7 Kcal/m^2/year, which is in the same range as values reported for the highly productive Georges Bank region.

4) If our assessment is correct, then cetaceans must be considered a major component of the ecosystem. Their impact on resources of the region is substantial—perhaps equal to, or comparable to, that of man.

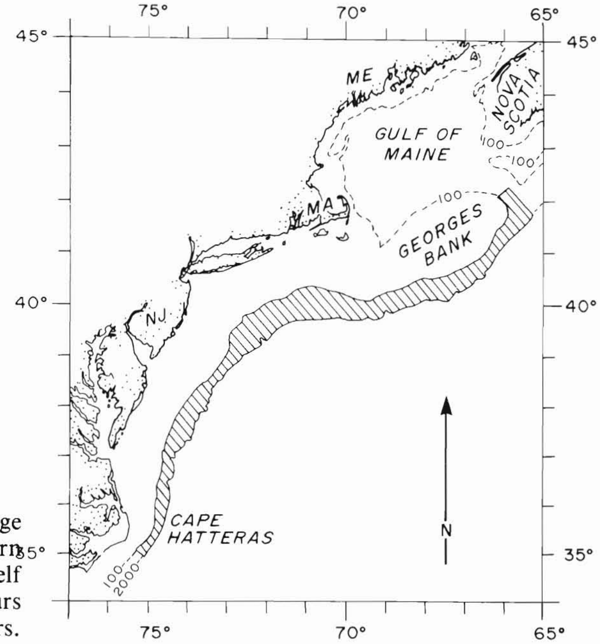

Figure 1.—The shelf-edge region of the northeastern U.S. outer continental shelf (lined area). Depth contours are labelled in meters.

Species Present

In the 39 months of field studies from November 1978 through January 1982, 2,519 cetacean sightings were reported from the defined shelf-edge region. These sightings are listed in Table 1 by species or species groups, along with two categories into which unidentified or partially identified sightings were grouped. Twenty species or species groups were reported. Of these, 12 were common (10 or more sightings) and 8 were uncommon or rare (<10 sightings). Sperm whales and fin

Table 1.—Cetaceans reported from the shelf edge region of the northeastern U.S. OCS. Data from CETAP field studies, November 1978-January 1982.

Species	Common name	No. of sightings
Mysticetes—baleen whales		
Balaenoptera physalus	Fin whale	91
B. acutorostrata	Minke whale	34
B. borealis	Sei whale	27
Megaptera novaeangliae	Humpback whale	6
Eubalaena glacialis	Right whale	3
Odontocetes—toothed whales		
Tursiops truncatus	Bottlenose dolphin	531
Globicephala spp.[1]	Pilot whales	347
Grampus griseus	Grampus	332
Delphinus delphis	Saddleback dolphin	197
Physeter catodon	Sperm whale	156
Stenella coeruleoalba	Striped dolphin	48
Stenella spp. (spotted)[1]	Spotted dolphin	27
Lagenorhynchus acutus	Whitesided dolphin	22
Phocoena phocoena	Harbor porpoise	17
Mesoplodon spp.[1]	Beaked whales	6
Orcinus orca	Killer whale	3
Ziphius cavirostris	Goosebeaked whale	3
Lagenorhynchus albirostris	Whitebeaked dolphin	3
Hyperoodon ampullatus	Northern bottlenose whale	1
Pseudorca crassidens	False killer whale	1
Unidentified large whales[2]		144
Unidentified small whales[2]		520
Total sightings		2,519

[1] Identification to genus level only due to difficulty in field identification and/or unresolved taxonomy.
[2] Categories used to group unidentified or partially-identified sightings: Large whales, ≥25 feet (7.6 m) in length; small whales, <25 feet (7.6 m) in length.

[1]Final Report of the Cetacean and Turtle Assessment Program, University of Rhode Island, to the Bureau of Land Management, U.S. Department of the Interior. Ref. No. AA551-CT8-48, 568 p.

Table 2.—Estimated abundance, biomass, and food requirements for cetaceans in the shelf edge region of the northeastern U.S. OCS.

Species		Abundance estimate[1] [2] (No. +/− 95% CI)	Total biomass (t)	Percent of total cetacean biomass	Weight[3] (t)	Food requirement[4] (t/year)
P. catodon	sp	215 +/− 256	4,300	16	20.0	6,016
	wi	65 +/− 197	1,300	18		
B. physalus	sp	292 +/− 426	8,760	33	30.0	10,250
	wi	60 +/− 102	1,800	24		
B. borealis	sp	237 +/− 327	3,081	12	13.0	3,686
	wi	0	0	0		
B. acutorostrata	sp	47 +/− 57	212	1	4.5	330
	wi	0	0	0		
H. ampullatus	sp	9 na	42	< 1	4.7	65
	wi	0	0	0		
Unidentified large whales	sp	2 +/− 6	41	< 1	[5]20.5	44
	wi	0	0	0		
T. truncatus	sp	6,431 +/− 4,001	965	4	0.15	4,320
	wi	1,458 +/− 1,885	219	3		
Globicephala spp.	sp	6,823 +/− 6,934	5,800	22	0.85	19,137
	wi	2,693 +/− 3,817	2,289	31		
Grampus griseus	sp	3,543 +/− 4,350	1,205	5	0.34	3,952
	wi	364 +/− 1,254	124	2		
D. delphis	sp	13,881 +/− 19,734	902	3	0.07	8,652
	wi	15,703 +/− 24,071	1,021	14		
Stenella spp.	sp	13,210 +/− 11,334	713	3	0.05	4,317
	wi	3,754 +/− 3,004	203	3		
L. acutus	sp	1,231 +/− 1,931	148	< 1	0.12	570
	wi	0	0	0		
P. phocoena	sp	140 +/− 163	6	< 1	0.05	34
	wi	15 +/− 34	1	< 1		
Unidentified small whales	sp	1,504 +/− 2,206	331	1	[5]0.22	2,593
	wi	2,050 +/− 7,529	451	6		
Total	sp	47,565	26,506			63,966
	wi	26,162	7,408			

[1] Estimates based on individuals sighted at or near the surface and do not account for animals missed due to submergence. Additional discussion in text.
[2] Estimates and biomass data shown for peak values in spring (sp) and minimum values in winter (wi).
[3] Weight values are from Kenney et al. (text footnote 3).
[4] Calculation based on 6 months at high spring abundance and 6 months at low winter abundance. Definition of seasons follows calendar conventions, e.g., spring = 20 March-20 June.
[5] Estimated body weight for this grouping is a weighted mean from the identified large or small whales.

whales were the most common large whales present. The majority of small whale sightings were made up of four species (or species groups): *Tursiops truncatus, Globicephala* spp., *Grampus griseus,* and *Delphinus delphis.* Together these six taxa made up 89 percent of the identified sightings.

Abundance and Biomass

Table 2 summarizes abundance and biomass data for cetaceans in the shelf-edge region. These abundance estimates are based on aerial survey data with calculations following the methods of Burnham et al. (1980). Because these data are based solely on aerial surveys in a rigorously defined census mode, they are from a subset of the total data given in Table 1. Several differences will be noted. For example, aerial observers pooled all sightings within the genus *Stenella,* since species were virtually indistinguishable in the field. Also, while humpback whales, *Megaptera novaeangliae,* and right whales, *Eubalaena glacialis,* are known to occur in the area (Table 1), none were sighted on census tracks, and are therefore not included in Table 2.

These data suggest that during the season of peak abundance, spring, the shelf-edge region may be inhabited by 47,565 individuals with a combined biomass of 26,506 t. This inhabitance is seasonal, and the low value for estimated biomass in winter is about 28 percent of the spring season high. Averaged over the whole year, three species or species groups, *P. catodon, B. physalus,* and *Globicephala* spp., constitute 75 percent of the total cetacean biomass. Five more species or species groups, *B. borealis, T. truncatus, Grampus griseus, D. delphis,* and *Stenella* spp., each accounting for 3-9 percent of the total biomass, bring the total to 99 percent. The remaining species together account for about 1 percent of the total biomass. (This treatment does not include the two unidentified whale categories.) Therefore, of the 20 species reported, three species form the principal component of the cetacean biomass, and eight species account for nearly the entire biomass.

Food Requirements: Estimated Minimum Values

The role of cetaceans in the shelf-edge ecosystem can be further described through the calculation of the food requirements of this component. Following the methods of Brody (1945) and Hinga (1979), the minimum metabolic demands, and thus the minimum food requirements, can be calculated from the following equation:

$$\text{Resting or basal metabolism } \left(\frac{\text{Kcal}}{\text{day}}\right) = 70 \times (\text{body wt. in kg})^{0.75}.$$

The conversion of caloric demand to weight value of prey species is from Sissenwine et al. (1984a):

1 Kcal/g wet weight.

The calculated annual food requirements are given in the righthand column of Table 2. Here, individual food requirements have been multiplied by the estimated abundance. The seasonal fluctuation in numbers has been accounted for in the calculations: The total requirement is based on 6 months at the high spring estimate and 6 months at the low winter estimate. This treatment achieves our aim of a concise presentation of findings, yet is consistent with the larger and considerably more detailed data set.

The summed values suggest that the minimum food requirement of the shelf-edge cetaceans is on the order of 64,000 t/year.

Estimated Food Requirements: A Best Estimate and an Upper Boundary

The figures presented in the foregoing are thought to be an underestimate. This is due to a number of factors:

1) Metabolic rate. Our calculations provide values for basal metabolism. The actual metabolic requirements will be greater, between 1.5 and 3 times the basal rate (Brodie, 1975; Brody, 1945; Hinga, 1979).

2) Assimilation efficiency. An animal cannot utilize all of the energy in its food. Lockyer (1981) gives an assimilation efficiency of 80 percent for cetaceans, resulting in a feeding rate of 1.25 the metabolic requirements.

3) Food storage. Many cetacean species store food energy in the blubber and elsewhere for periods of reduced feeding common to their seasonal cycles. Building up this reserve requires increased food intake while in productive feeding areas. The correction for this factor very likely lies in the range of 1.25-2.00.

4) Submerged animals missed by surveys. Aerial surveys result in estimates based on individuals sighted at or near the surface. The estimates are negatively biased by individuals not sighted due to submergence. At present, this factor can only be gauged in a preliminary way. In one study, fin, humpback, and right whales were shown to spend 25-65 percent of their time at the surface (footnote 1). Short dive routines of 2-6 minutes were reported to be common in fin whales, although dives of 6-14 minutes (or longer) were also observed (Watkins, 1981). In the Caribbean, dives of an hour or more were not unusual for sperm whales, and estimates based on underwater sounds were nearly four times higher than those based on surface sightings made from a small research vessel (Watkins and Moore, 1982). This factor is clearly highly variable (Leatherwood et al., 1982), and a correction lies in the range of 1.5-5.0.

Applying the cumulative corrections, the actual requirements are almost certain to be 2-3 times greater than the calculated minimums. For species which ordinarily spend a good portion of their time submerged and also require additional food intake to build up substantial stored food reserves, the requirement could be from 6 to 16 times greater. Particularly since sperm and fin whales are shown to be a major component of the total cetacean biomass—both species with storage requirements and apparently considerable submergence times—the upward correction to our minimum estimate will be a substantial one. To arrive at a best estimate, we select correction factors from within the ranges given as follows: a) Metabolism beyond basal metabolism—2×, b) assimilation efficiency—1.25×, c) food storage requirements—1.5×, and d) noncensusing of submerged animals—2×. Summing these values yields a total upward correction of 7.5× and a best estimate of 480,000 t/year as the annual food requirement of cetaceans within the defined region.

Using a less conservative selection of correction factors and similarly summing the values (total correction = 15×) yields an upper boundary to our estimates of 960,000, or about 1 million t/year.

These estimates will almost surely be improved upon as additional data become available. For the present, they provide an advance over what has previously been known, and a useful measure of the role of cetaceans in the shelf-edge region.

Conclusions

The role of marine mammals in the ecosystem is likely greater than has been previously recognized. For the period 1979-82 (corresponds to the cetacean data), the current best estimate for the abundance of squid and finfish in the shelf waters of the northeastern United States (includes other than the defined shelf-edge region) is on the order of 3.4 million t/year (NEFC, 1983). The commercial fishery catch for this same period was on the order of 0.5 million t/year (NEFC, 1983; footnote 2). (As above, values are for entire shelf, Gulf of Maine to Cape Hatteras, and not only the shelf-edge region.)

If our assessment is correct, the food requirement of shelf-edge cetaceans is 480,000 t/year and could approach 1 million t/year. Even after all qualifications have been considered (e.g., cetaceans feeding at various trophic levels, cetaceans feeding on species other than those considered by the foregoing National Marine Fisheries Service assessments), the impact of cetaceans on the available food resource is substantial, and is likely comparable with man's take.

To relate these findings to existing values, these estimates were converted to consumption per unit surface area following the methods of Cohen and Grosslein (In press). Dividing total consumption by the shelf-edge area and assuming, for the purposes of consistency, that 1 g wet weight equals 1.25 Kcal, cetacean consumption converts to 9.7 Kcal/m^2/year, with an upper estimate of 19.3 Kcal/m^2/year. Calculations based on estimates given in Winn et al. (In press) yield comparable values for Georges Bank of 6.3 and 12.6 Kcal/m^2/year. Allowing for uncertainties in the estimates, indications are that consumption by marine mammals in the shelf edge region is in the same range as for the Georges Bank region.

As fishery scientists and managers seek to improve their understanding of the biology of the resource and its successful management, an area of current interest is in the improved estimation of natural mortality and the partitioning of its components. Recent work has shown predation by marine mammals to be an important element (Kenney et al.[3]; Scott et al.,

[2]The fisheries estimates are for all commercially exploited species of finfishes and squids except highly migratory species such as billfishes, tunas, and large sharks, and inshore species such as menhaden, American eel, and white perch.

[3]Kenney, R. D., M. A. M. Hyman, and H. E. Winn. 1983. Calculation of standing stocks and energetic requirements of the cetaceans of the northeast United States outer continental shelf. Natl. Mar. Fish. Serv. Rep. NA-83-FA-C-0009, 154 p.

1983; Winn et al., In press; and this paper). This factor has, for example, been recently addressed by Sissenwine et al. (1984b) in analyzing the decline of the Georges Bank herring stock.

With respect to offshore oil and gas development, the effects of man's interaction with marine mammals are not yet clear. Several preliminary studies indicate a lack of conspicuous negative impacts on marine mammals (Geraci and St. Aubin[4]; Sorensen et al., 1984). However, other parts of these same studies also suggest possible problems due to ingestion and contact, as well as long-term chronic effects (Geraci and St. Aubin[4]).

On both counts, the conservation and wise management of marine mammals is a national policy (Marine Mammal Protection Act of 1972, Endangered Species Act of 1973). In addition, the effective management of our fishery resources requires an understanding of the role played by marine mammals. The assessments reported here should contribute to a wider view of the ecosystem, and to forthcoming decisions about the management of the shelf-edge region of the northeastern U.S. outer continental shelf.

[4]Geraci, J. R., and D. J. St. Aubin. 1982. Study of the effects of oil on cetaceans. Final report to the Bureau of Land Management, U.S. Department of the Interior. Ref. No. AA551-CT9-29, 274 p.

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